
201
AWESOME,
MAGICAL,
BIZARRE
&
INCREDIBLE
EXPERIMENTS

# Janice VanCleave's
# 201 Awesome, Magical, Bizarre, and Incredible Experiments

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# 201 Awesome, Magical, Bizarre, and Incredible Experiments

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*This book is dedicated to three special people who have given me much encouragement—to my friends, Jim, Nancy, and Matthew Land*

This text is printed on acid-free paper.



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## Introduction

This book is a collection of science experiments designed to show you that science is more than a list of facts—science is fun! The 201 experiments in the book take science out of the laboratory and put it into your daily life.

Science is a way of solving problems and discovering why things happen the way they do. How does a battery work? Why is Venus so hot? How can a frog build a nest in a tree? You'll find the answers to these and many other questions by doing the experiments in this book.

The experiments cover five different fields of science:

• **Astronomy** The study of the planet we live on—Earth—and all our neighbors in space.

• **Biology** The study of the way living organisms behave and interact.

• **Chemistry** The study of the way materials are put together and their behavior under different conditions.

• **Earth Science** The study of the unique habitat that all known living creatures share—the Earth.

• **Physics** The study of energy and matter and the relationship between them.

### The Experiments

Scientists identify a problem, or an event, and seek solutions, or explanations, through research and experimentation. A goal of this book is to guide you through the steps necessary to successfully complete a science experiment and to teach you the best method of solving problems and discovering answers.

1. **Purpose:** The basic goals for the experiment.

2. **Materials:** A list of necessary supplies.

3. **Procedure:** Step-by-step instructions on how to perform the experiment.

4. **Results:** An explanation stating exactly what is expected to happen. This is an immediate learning tool. If the expected results are achieved, the experimenter has an immediate positive reinforcement. An error is also quickly recognized, and the need to start over or make corrections is readily apparent.

5. **Why?** An explanation of why the results were achieved is described in terms that are understandable to the reader who may not be familiar with scientific terms. When a new term is introduced and explained, it appears in **bold** type; these terms can also be found in the Glossary.

You will be rewarded with successful experiments if you read an experiment carefully, follow each step in order, and do not substitute materials.

## General Instructions

1. **Read first.** Read each experiment completely before starting.

2. **Collect needed supplies.** You will experience less frustration and more fun if all the necessary materials for the experiments are ready for instant use. You lose your train of thought when you have to stop and search for supplies.

3. **Experiment.** Follow each step very carefully, never skip steps, and do not add your own. Safety is of the utmost importance, and by reading the experiment before starting, then following the instructions exactly, you can feel confident that no unexpected results will occur.

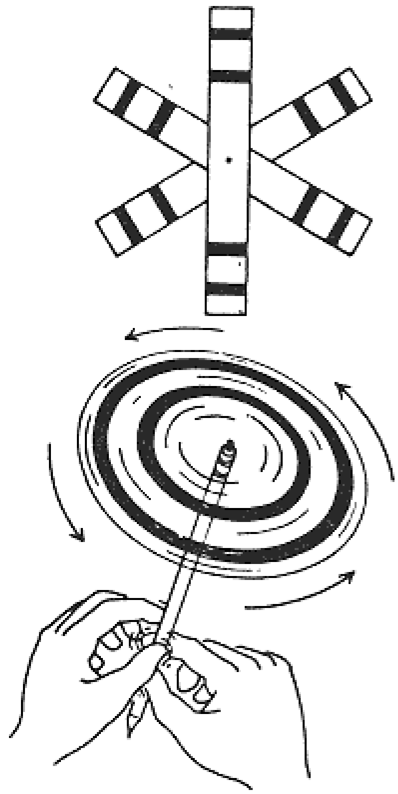
4. **Observe.** If your results are not the same as described in the experiment, carefully read the instructions, and start over from the first step.

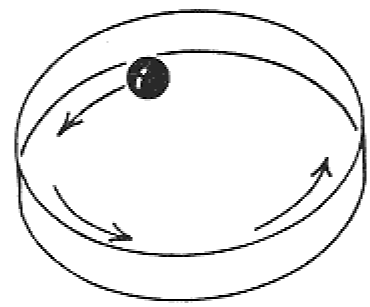
## Measurements

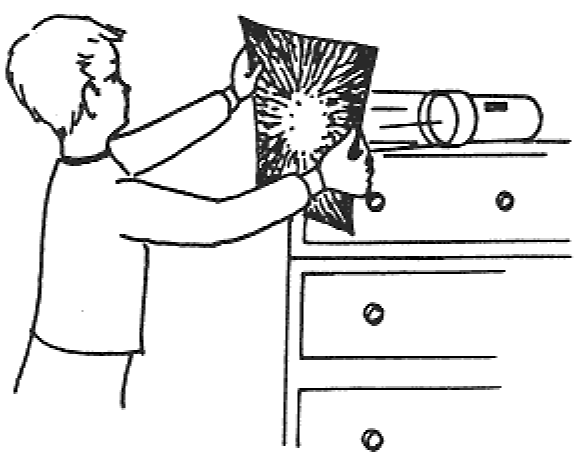
Measuring quantities described in this book are intended to be those commonly used in every kitchen. When specific amounts are given, you need to use a measuring instrument closest to the described amount. The quantities listed are not critical, and a variation of very small amounts more or less will not alter the results. Approximate metric equivalents are given in parentheses.

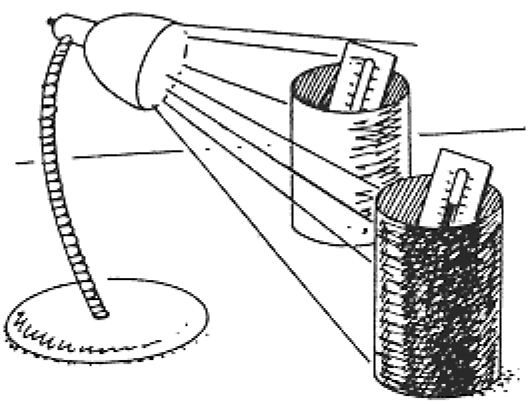
## Contents

# I—
# Astronomy









**1—**
**Cooler**

***Purpose***

To determine how color affects a planet's surface temperature.

***Materials***

scissors
construction paper (1 piece white and 1 piece black)
2 empty, metal, food cans, same size
CAUTION: *Be sure rims are not jagged. They might cut your hands.*
transparent tape
2 thermometers
ruler
desk lamp

***Procedure***

• Cut the white and black construction paper to fit around the outside of the cans, much as the can label does.

• Secure one piece of paper to each can with tape.

• Place one thermometer inside each can.

• Read and record the temperature on both thermometers.

• Position both cans about 12 inches (30 cm) from the lamp.

• Turn the lamp on.

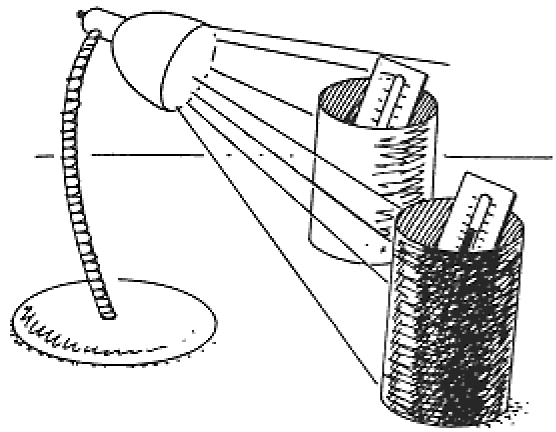
• Read and record the temperature on both thermometers after 10 minutes.

***Results***

The temperature is much higher in the can covered with black paper.

***Why?***

The dark paper absorbs more light waves than the white paper. The white paper is cooler because it reflects more of the light waves than the black paper. The absorption of the light waves increases the temperature of a material. In the same way, the lighter the surface material on a planet, the less light energy the planet's surface absorbs and the cooler is its surface.



**2—**
**Shaded**

***Purpose***

To demonstrate how a planet's surface temperature can vary.

***Materials***

2 thermometers

***Procedure***

• Read and record the temperature on both thermometers.

• Place one thermometer on the ground in the shade of a tree or other large structure.

• Place the second thermometer on the ground, but in direct sunlight.

NOTE: *It is important that both thermometers be placed on the same type of surface (grass works well).*

• Read and record the temperature on both thermometers after 20 minutes.

***Results***

The temperature on the surface in the shade is lower than the same surface in direct sunlight.

***Why?***

The tree or large structure blocks some of the light rays, producing a shaded area on the ground. This protected surface area is cooler due to the decrease in light energy received. The same type of surface in direct sunlight receives more light energy and becomes hotter. In the same way, the temperature of planet surfaces can vary depending on whether the landscape has large structures to provide shade.

## 3—
## Cover Up

### *Purpose*

To determine why Mercury does not cause an eclipse.

### *Materials*

desk lamp

### *Procedure*

• Stand about 2 yards (2 m) from the desk lamp.

• Close your right eye.

• Hold your left thumb at arm's length in front of your left eye and in front of the lamp.

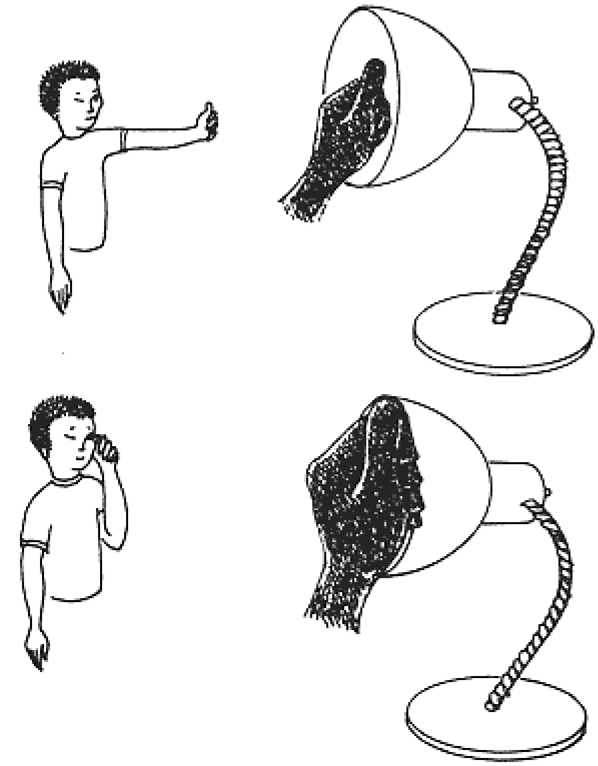
• Slowly move your thumb toward your face until it is directly in front of your open eye.

### *Results*

The farther your thumb is from your eye, the smaller your thumb appears and the more of the lamp you see.

### *Why?*

Your thumb blocked the light moving from the lamp toward your eye. The closer your thumb is to your face, the more light it blocks. Because Mercury is very close to the Sun, it blocks only a small portion of the Sun's light, as did your thumb when held close to the lamp. The shadow made by Mercury is so small that it does not spread out enough to fall on the Earth, but lands in space. For this reason, Mercury does not cause a **solar eclipse** (blocking of some of the sunlight from parts of the Earth).



## 4—
## Thick

### *Purpose*

To determine why Venus' atmosphere is so hard to see through.

### *Materials*

flashlight
wax paper

### *Procedure*

• Turn the flashlight on and place it on the edge of a table.

• Stand about 2 yards (2 m) from the table.

• Face the light and observe its brightness.

• Hold the sheet of wax paper in front of your face.

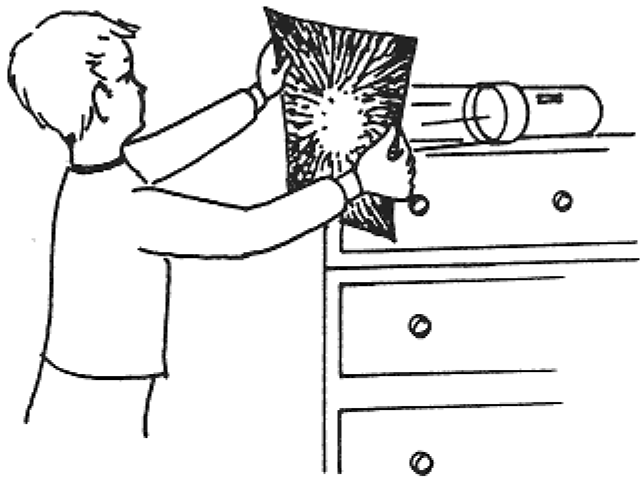
• Look through the wax paper at the light.

### *Results*

The light looks blurred through the paper.

### *Why?*

The light rays bend and bounce off the wax paper. This is similar to the way sunlight bends and bounces off the thick clouds that surround Venus, which are not particularly dark, just very thick. In their thickest part, the visibility is about 0.6 miles (1 km) or less. This low visibility would result in the closing of most airports on Earth.



## 5—
## Hot Box

***Purpose***

To determine why Venus is so hot.

***Materials***

2 thermometers
1 jar with lid (tall enough to hold one of the thermometers)

***Procedure***

• Put one thermometer inside the jar and close the lid.

• Place the second thermometer and the jar near a window in direct sunlight.

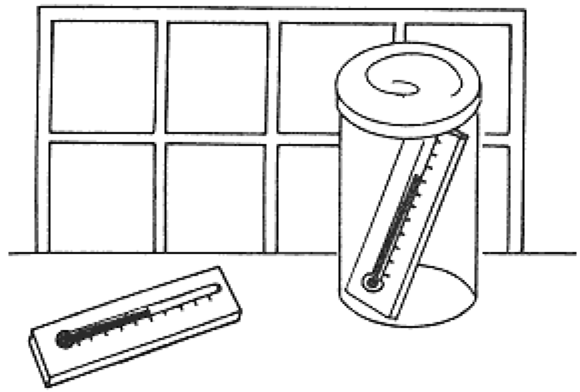
• Record the temperature on both thermometers after 20 minutes.

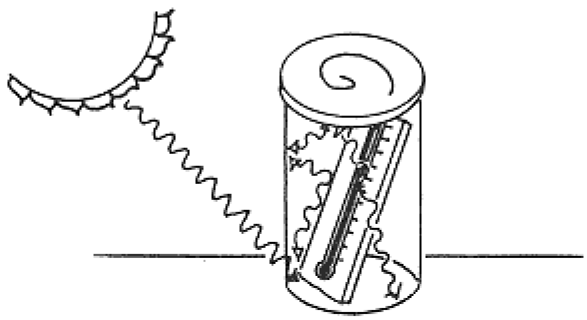
***Results***

The temperature inside the closed jar is higher than outside the jar.

***Why?***

The glass jar is used to simulate the trapping of infrared light waves by gasses in the atmosphere around planets. The thick atmosphere around Venus allows short wave radiation through, but blocks long wave radiation. The trapped long wave **infrared light** warms the planet's surface to about 800 degrees Fahrenheit (427°C).





**6—**
**Sun Prints**

***Purpose***

To determine what might cause Jupiter's colored clouds.

***Materials***

scissors
cardboard
double-sided tape
photographic paper (This can be purchased at a photography store, or ask your local newspaper or high school photography club for a sheet of outdated photographic paper. Keep it out of the sunlight.)

***Procedure***

• Cut a heart shape out of the cardboard.

• In a semidarkened room, use the double-sided tape to stick the heart to the glossy side of the photographic paper.

• Take the paper outside and allow the Sun to shine directly on the paper for 1 minute.

• Return to the darkened room and take the paper heart off the photographic paper.

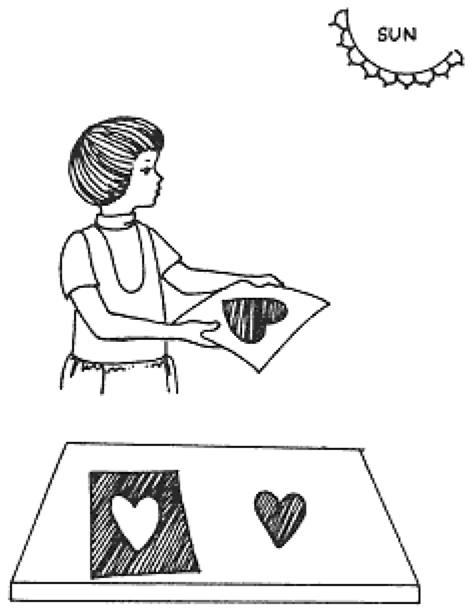
***Results***

The photographic paper is unchanged under the cardboard. A light-colored, heart-shaped design is

surrounded by a dark background.

***Why?***

The photographic paper turns dark only where light hits it. This change is because the light activates the molecules on the glossy surface of the paper. Scientists think that the colors in Jupiter's atmosphere may come from chemicals in the clouds that change color because of lightning or that the Sun changes the colors as it did the special light-sensitive photographic paper.



## 7— Hot

### *Purpose*

To determine if conservation of energy applies to friction between molecules in a dense atmosphere.

### *Materials*

your hands

### *Procedure*

• Place your palms together.

• Quickly rub your dry hands back and forth several times.

### *Results*

Your dry hands feel hot when rubbed together.

### *Why?*

Friction between your hands produces heat energy, as does the friction between any moving objects. **Friction** is a force that tends to stop objects sliding past each other. The closer and faster the objects in motion are, the greater is the heat. This would make one think that the dense **atmosphere** around planets such as Jupiter would cause an increase in the surface temperature. The winds around Jupiter blow in excess of 800 miles (1,280 km) per hour. The atmospheric gases are constantly being rubbed together, but the temperature on the planet does not increase continuously. The temperature on the planet Jupiter remains constant due to **conservation of energy** (heat gained by one substance is equal to the heat lost by some other substance).

## 8—

## Charged

### *Purpose*

To determine why lightning continually flashes on Jupiter.

### *Materials*

scissors
ruler
thin sheet of plastic (plastic report cover)
wool cloth (use any 100 percent wool coat, scarf, sweater, etc.)

### *Procedure*

• Cut a plastic strip about 2 × 8 inches (5 × 20 cm).

• In a dark room, hold the end of the plastic strip. Wrap the wool cloth around the plastic, then quickly pull the plastic through the cloth.

• Repeat this 5 or 6 times.

• Observe the cloth as you pull the plastic through it.

### *Results*

A bluish light is seen in the folds of cloth that touch the plastic.

### *Why?*

**Electrons** are negative particles that spin around a positively charged **nucleus** of an atom. Some of these electrons are rubbed off the wool and onto the plastic strip. The wool becomes positively charged and the plastic negatively charged. When the electrons leap from the plastic back to the wool, an electric spark is created. Flashes of light are continually seen through the clouds that swirl around Jupiter. The molecules in the **atmosphere** are briskly rubbed together because of the winds that blow up to 800 miles (1,280 km) per hour. The rubbing of the molecules in the atmosphere, like the rubbing of the wool cloth on the plastic, can result in electric sparks.

## 9—
## See Through

### *Purpose*

To determine how Saturn can be seen through its rings.

### *Materials*

| | |
|---|---|
| scissors | black marking pen |
| ruler | straight pen |
| white poster board | pencil |
| glue | adult helper |

### *Procedure*

• Cut 3 strips from the poster board that are each 1 × 6 inches (2.5 × 15 cm).

• Evenly space the strips so that their centers cross.

• Glue the centers of the strips together.

• Use the marking pen to make two marks across the ends of each strip. Start the first mark 1/2 inch (1 cm) from the end of the strip and make the second mark 1 inch (2.5 cm) from the end.

• Ask an adult to insert the pin through the center of the strips. Use the pin to enlarge the hole so that the paper blades easily spin. Then stick the end of the pin in a pencil eraser.

• Spin the paper blades.

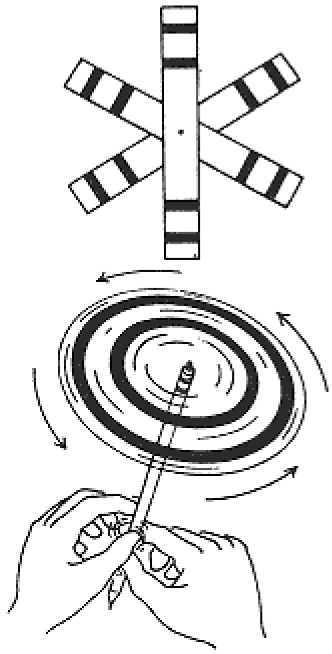
• Observe the spinning blades.

### *Results*

Two black rings are seen, but you can see through the spinning blades.

### *Why?*

Your eyes blend the color on the paper strips as they spin, producing what appears to be solid rings. The rings around Saturn are made of chunks of ice and rock. Their movement makes them appear to be a continuous surface as does the movement of the black marks on the spinning paper.



**10—**
**Spinner**

### *Purpose*

To determine why planets move smoothly around the Sun.

### *Materials*

| | |
|---|---|
| 10-inch (25-cm) diameter cake pan | scissors ruler |
| pencil | heavy, thick string |
| sheet of paper | 4 large paper clips |
| cardboard | adult helper |

### *Procedure*

- Use the cake pan to draw a circle on the paper and the cardboard.
- Cut the circles out.
- Fold the paper in half twice to find the center of the circle.
- Ask an adult to lay the paper over the cardboard circle and make a hole through the center of both

circles with the point of a pencil.

• Discard the paper.

• Cut a 1-yard (1-m) length of string.

• Thread one end of the string through the hole in the cardboard circle, and tie a knot on the other side to keep it from pulling back through.

• Evenly space the 4 paper clips around the outer rim of the cardboard circle or disk.

• Hold the end of the string and swing the disk back and forth.

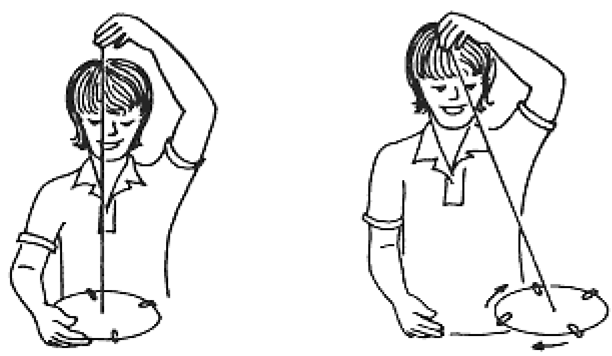
• Continue to hold the end of the string while you give the disk a quick spin toward you, then swing it as before.

***Results***

The disk flops around when merely moved around on the string, but when spun, it rotates in the plane in which it was originally spun.

***Why?***

The cardboard disk acts like a **gyroscope,** a kind of top whose axis always points in the same direction while spinning. The planets spin on their axis as they rotate around the Sun. This keeps them turning in the plane in which they were started just as the disk does.



## 11—
## On the Move

### *Purpose*

To determine why planets continue to move.

### *Materials*

round cake pan
pencil
1 sheet construction paper
scissors
1 marble

### *Procedure*

• Use the cake pan to trace a circle on the paper.

• Cut the circle out.

• Place the pan on a flat surface.

• Lay the paper inside the pan and place the marble on top of the paper.

• Thump the marble so that it rolls around next to the wall of the pan.

• Remove the paper from the pan.

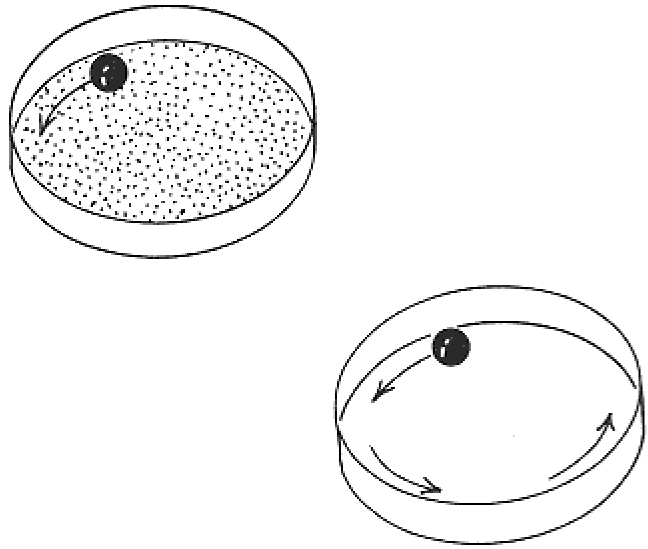
• Again, thump the marble so that it rolls around next to the wall of the pan.

### *Results*

The marble rolls in a circular path. It rolls farther and faster without the paper lining in the pan.

### *Why?*

**Inertia** is the resistance that all objects have to any change in motion. Inertia causes stationary objects to remain at rest and moving objects to continue to move in a straight line, unless some force acts on them. The marble stopped moving more quickly in the paper-lined pan because of **friction.** When the friction between the pan and the marble was reduced, the marble rolled for a longer time. The planets continue to move around the Sun because their movement through space is not restricted by friction.



**12—**
**Speedy**

***Purpose***

To determine the effect of distance on the orbiting speed of planets.

***Materials***

1 metal washer
1-yard (1-m) piece of string

***Procedure***

NOTE: *This activity is to be performed in an open, outside area away from other people.*

• Tie the washer to the end of the 1-yard (1-m) length of string.

• Hold the end of the string and extend your arm outward.

• Swing your arm around so that the washer moves in a circular path beside your body.

• Spin the washer at the slowest speed necessary to keep the string taut.

• Hold the string in the center and spin the washer at the slowest speed necessary to keep the string taut.

• Hold the string about 10 inches (25 cm) from the washer and spin as before.

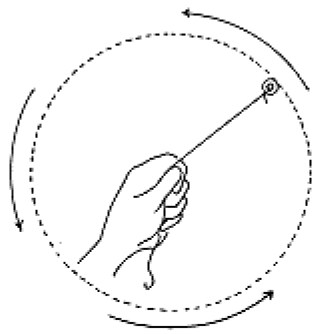
***Results***

As the length of the string decreases, the washer must be spun around more times in order to keep the string taut.

***Why?***

The washer seems to move sluggishly around in its circular path when attached to a long string, while

on a shorter string, it zips around quickly. This is also true about planets, which differ in their distance from the Sun. As the planet's distance from the Sun increases, the pull toward the Sun, called **gravity** (the force that pulls celestial bodies toward each other), decreases. With less pull toward the Sun, the orbiting speed of the planet decreases. Mercury, the closest planet to the Sun, has the fastest orbiting speed and Pluto, the furthermost planet, has the slowest orbiting speed. (Twirling the washer on the string is not a true simulation of how planets move around the Sun, because planets are not attached to the Sun by a cord and do not move in a circular path.)



## 13— Expanding

### *Purpose*

To demonstrate how galaxies may be moving.

### *Materials*

9-inch (23-cm) round balloon
black marking pen
mirror

### *Procedure*

• Inflate the balloon so that it is about as large as an apple.

• Use the marking pen to randomly make about 20 dots on the balloon.

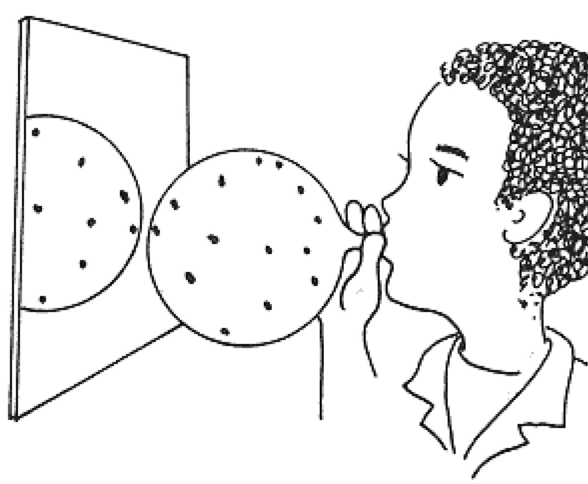
• Stand in front of a mirror and observe the dots as you inflate the balloon.

### *Results*

The dots move away from each other. Some seem to move farther than others, but no dots get closer together.

### *Why?*

Astronomers believe that the **galaxies** (large systems of stars) are moving away from each other similarly to the way the dots on the balloon move. Not all the galaxies are moving away from us at the same rate. In 1929, Dr. Edwin Hubble discovered that the farther away a galaxy is, the faster it seems to be moving away from us. Since no two galaxies seem to be getting closer as they move, scientists believe the universe is expanding.



## 14— Balancing Point

***Purpose***

To demonstrate the position of the Earth's barycenter.

***Materials***

scissors
ruler
string
pencil
modeling clay

***Procedure***

• Cut the 12-inch (30-cm) length of string.

• Tie the string about 1 inch (3 cm) from the end of the pencil.

• Make a ball of clay, about the size of a lemon.

• Stick the clay ball on the end of the pencil with the string.

• Mold the clay around the string so that the string is barely inside the edge of the clay ball.

• Add a grape-size piece of clay to the opposite end of the pencil.

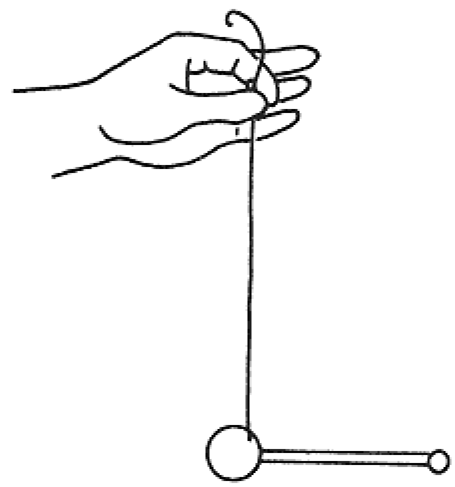
• Hold the end of the string and add small pieces of clay to the end of the pencil until the pencil balances horizontally.

***Results***

The pencil hangs in a horizontal position.

***Why?***

The **center of gravity** (balancing point) of the Earth-Moon system is called the **barycenter.** The barycenter is about 2,720 miles (4,352 km) beneath the Earth's surface on the side of Earth facing the Moon, and it is the point at which the Earth-Moon system moves around the Sun. The string represents the Earth's barycenter on the Earth-Moon model.



## 15—
## Lifter

### *Purpose*

To demonstrate how the atmosphere affects falling objects.

### *Materials*

paper
book larger than the paper

### *Procedure*

• Position the paper on top of the book so that half of the paper is hanging over the edge of the book.

• Drop the book and paper from a waist-high position.

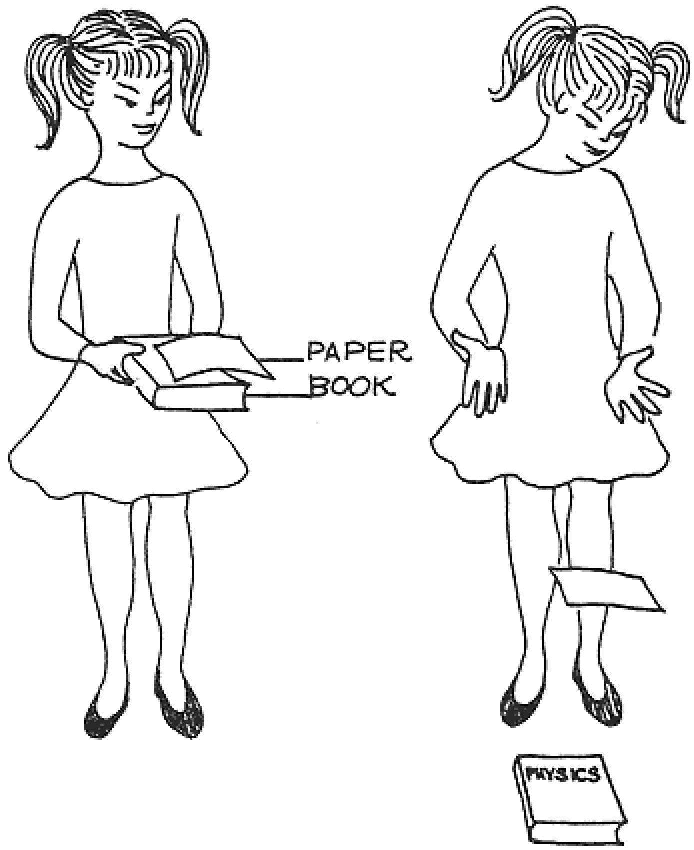
• Observe the paper and book as they fall and strike the ground.

### *Results*

The paper leaves the book and falls more slowly.

### *Why?*

Objects push against air molecules in the Earth's **atmosphere** as they fall. These air molecules push back against the falling object causing its speed to decrease. The speed of the falling book is greater than that of the paper because its **weight** (downward force due to gravity) is so much greater than the upward push of the air.




**16—
In and Out**

***Purpose***

To demonstrate forces that keep satellites in orbit.

***Materials***

| | |
|---|---|
| scissors | masking tape |
| yardstick (meter stick) | thread spool |
| string | metal spoon |

***Procedure***

• Cut 1 yard (1 m) of string.

• Tie one end of the string to the roll of tape.

• Thread the free end of the string through the hole in the spool.

• Tie the spoon to the free end of the string.

• Stand in an open area holding the tape in one hand and the spool with your other hand.

• Give the spool a quick circular motion to start it spinning in a horizontal circle above your head.

• Release the tape and allow it to hang freely.

• Keep the spoon spinning by moving the thread spool in a circular motion.

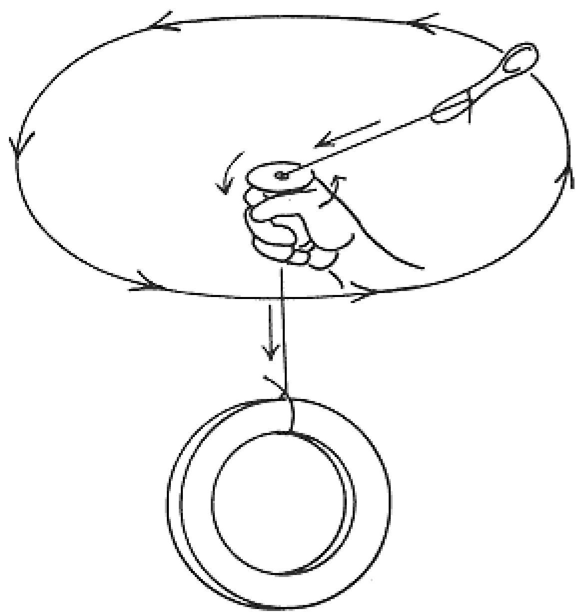
• Observe the movement of the tape roll.

***Results***

The spoon spins in a circular path with only the weight of the tape pulling on the attached string.

***Why?***

Any circling object, spoon or **satellite,** has a **centripetal force** (force directed toward the center) keeping it in its circular path. Moons that orbit planets and planets that orbit the Sun are all pulled toward the celestial body that they orbit. Their own forward speed keeps them from being pulled into the body that they orbit, and the centripetal force acting on the orbiting bodies keeps them from moving off into space.



## 17—
## Same Place

### *Purpose*

To determine why satellites appear to be stationary.

### *Materials*

rope about 3 yards (3 m) long
helper

### *Procedure*

• In an open area outside, use a tree or other object to represent the Earth.

• Ask your helper to hold one end of the rope as you hold on to the other end.

• Have your helper stand near the tree.

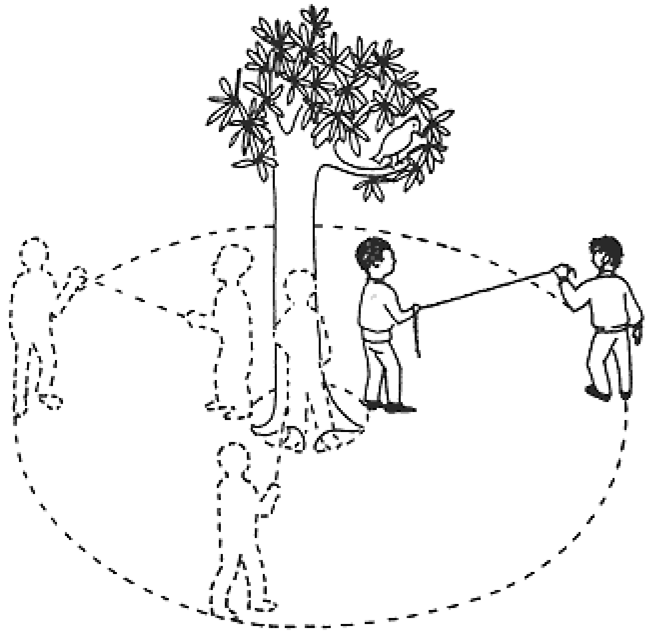
• Walk at a pace that keeps the rope tight and in a position so that you are in line with the same point on the tree as your helper.

### *Results*

The person in the outside circle moves faster, but stays in line with the person moving in the smaller inside circle.

### *Why?*

The distance around the outside of the circle is larger than the circle near the tree. A faster speed is required to travel around the larger circle in the same time that the person closer to the tree travels around the smaller circle. **Geostationary Operational Environmental Satellites (GOES)** are placed at about 22,500 miles (36,000 km) above the Earth. They move at a very fast speed, which gives them an orbital period of 24 hours, the same as that of the Earth; thus, the satellites appear to remain stationary above the Earth. There are more than 120 geostationary satellites positioned above the Earth's equator.



## 18— Attractive

### *Purpose*

To simulate the solar magnetic field.

### *Materials*

bar magnet
81/2 × 11 inch (22 × 28 cm) sheet of white paper
iron filings (found in magnetic drawing toys sold at toy stores)
small spray bottle
white vinegar
pencil

### *Procedure*

• Lay the magnet on a wooden table.

• Cover the magnet with the sheet of paper.

• Sprinkle iron filings over the surface of the paper.

• Gently tap the paper with your finger until the filings settle into a pattern.

• Fill the spray bottle 1/2 full with the vinegar.

• Spray a fine mist of vinegar over the iron filings on the paper.

• Allow the paper to remain undisturbed for an hour.

• Lift the paper and shake the iron filings into the trash.

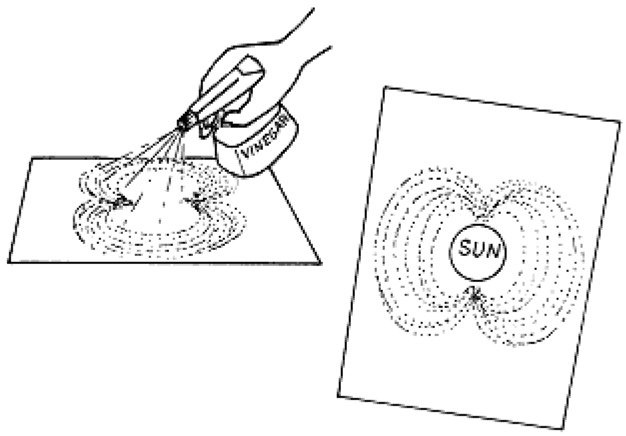
• Draw a circle in the center of the pattern left by the rusty filings and label it "Sun."

***Results***

The iron filings form curved lines around the magnet. Adding the vinegar makes the iron in the filings rust. When the filings are shaken off, the rust leaves marks on the paper where the filings were.

***Why?***

Every magnet has an invisible **magnetic field** around it. This field is made up of lines of force that attract magnetic material such as iron filings. The magnetic field of the Sun, like the bar magnet in this experiment, has a north and south pole. It is thought that the Sun's magnetic field may extend out of its north pole to the outer limits of our solar system (the orbit of Pluto) where it bends around and returns to the Sun's magnetic south pole.



## 19— Free Movers

### *Purpose*

To determine why different parts of the Sun rotate at different rates.

### *Materials*

2 2-quart (2-liter) plastic soda bottles
tap water
1 tea bag
washer (same diameter as the bottle's mouth)
paper towel
duct tape

### *Procedure*

• Fill one bottle 1/2 full with tap water.

• Open the tea bag and pour the tea leaves into the water.

• Cover the mouth of the bottle containing the water and tea leaves with the washer.

• Turn the second bottle upside down and place it on top of the washer.

• Use the paper towel to dry any moisture from the necks of the bottles.

• Wrap strips of tape around the necks of the bottles to secure them together tightly.

• Flip the bottles upside down and place the empty bottle on a table.

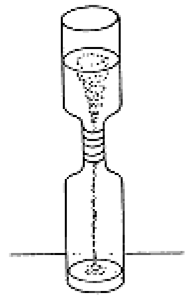
• Support the lower bottle with one hand and place the other hand on the top bottle. Swirl the two bottles several times.

### *Results*

The water and tea leaves swirl in a funnel shape as they pour out of the top bottle. The leaves in the funnel move at different rates.

### *Why?*

As the water swirls, it pulls the leaves around with it. They are not connected so each piece moves according to the speed of the water at different parts of the water funnel. The Sun is not a solid body, but a ball of spinning gasses. Like the leaves, all the gases do not move at the same rate. Therefore, the number of days it takes for parts of the Sun to complete one **rotation** (turning of an object about its own axis) varies. The rotation time at the Sun's equator is about 25 days and about 35 days at its poles.



**20—**
**Radiate**

***Purpose***

To determine how energy from the Sun travels through space.

***Materials***

baseball cap

***Procedure***

• Stand outside in the direct sunlight.

• Face the Sun for 5 seconds.

CAUTION: *Never look directly into the Sun because it can damage your eyes.*

• Position the cap on your head so that it shades your face.

• Stand with the cap on for 5 seconds.

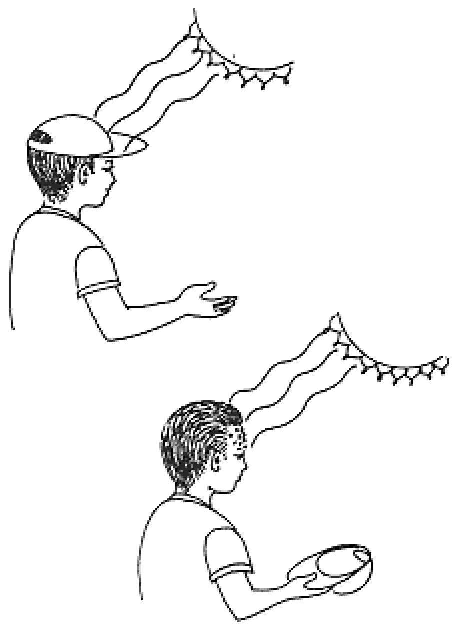
• Remove the cap, but remain in the same position for another 5 seconds.

***Results***

The skin on your face feels warmer without the cap.

***Why?***

**Radiation** is a process by which energy, such as heat, is transferred. Radiation also refers to the energy waves in the electromagnetic spectrum such as solar energy. The **electromagnetic spectrum** is a group of different energy waves that travel in a straight line at a speed of light which is 186,000 miles (3,000,000 km) per second and do not require the presence of matter. Thus, solar energy can travel through space where there is no matter. Because the heat waves travel in straight lines, the brim of the cap was able to block the waves from your face. It took 81/2 minutes for the energy waves to travel the 93 million miles (149 million km) from the Sun to your skin.



## 21—
## Blackout

***Purpose***

To demonstrate a solar eclipse.

***Materials***

coin

***Procedure***

• Close one eye and look at a distant tree with your open eye.

• Hold the coin at arm's length in front of your open eye.

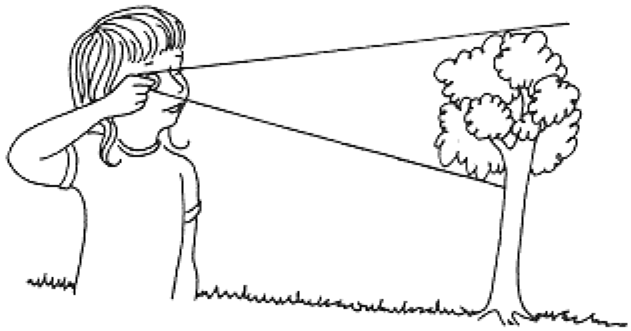
• Bring the coin closer to your open eye until it is directly in front of the eye.

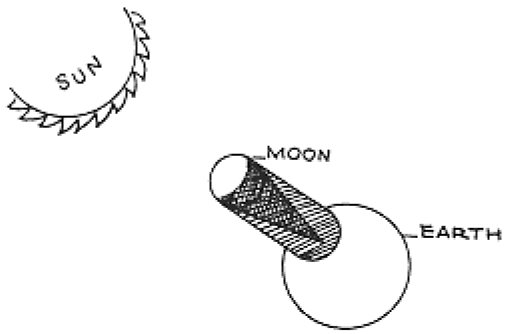
***Results***

As the coin is brought nearer to your face, less of the tree is seen until finally the tree is no longer visible.

***Why?***

The coin is smaller than the tree, just as the Moon is smaller than the Sun, but they both are able to block out light when they are close to the observer. When the Moon passes between the Sun and the Earth, it blocks out light just like the coin blocks your view of the tree. This is called a **solar eclipse.** The Moon moves around the Earth about once a month, but a solar eclipse does not occur monthly. The Moon does not orbit around the Earth's equator, and the Earth's axis is tilted, so the Moon's shadow misses the surface of the Earth most of the time.






**22—**
**Swirls**

### *Purpose*

To determine the color composition of sunlight.

### *Materials*

1 sheet of white paper
clear, plastic ballpoint pen

### *Procedure*

• Place the paper on a table near a window so that it receives the morning sunlight.

• Lay the pen on the paper so that the Sun's light hits it directly.

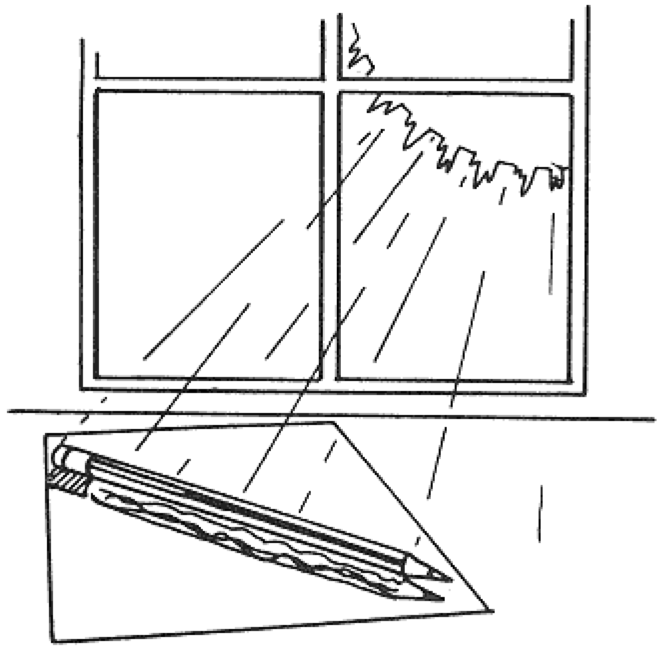
• Roll the pen back and forth on the paper very slowly.

### *Results*

Swirls of colors appear in the shadow made by the pen.

### *Why?*

The clear plastic acts like a **prism** (a transparent object that can break the white light of the Sun into its separate colors of red, orange, yellow, green, blue, indigo, and violet). You may not see each of these colors, but you can determine that there is a definite range of colors from red to violet.



## 23—
## Clock Compass

### *Purpose*

To demonstrate how a clock can be used as a compass.

### *Materials*

scissors
ruler
1 sheet of white paper
pencil
12 × 12 inches (30 × 30 cm) cardboard
straight pin
clock
compass

### *Procedure*

• Cut a 6-inch (15-cm) diameter circle from the paper.

• Write numbers on the paper circle as they appear on a clock.

• Lay the paper circle in the center of the cardboard.

• Stick a straight pin vertically through the center of the paper circle and into the cardboard.

• Place the cardboard on an outside surface in direct sunlight.

• Turn the paper circle until the shadow of the pin falls on the correct time. Do not use daylight savings time.

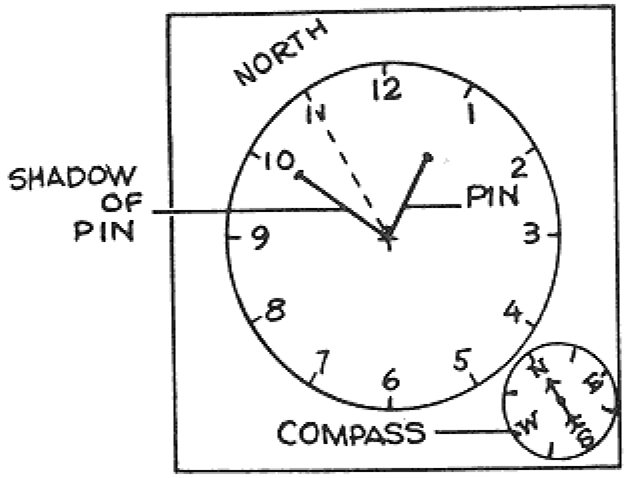
### *Results*

North will be halfway between the shadow and the number 12 on your paper clock.

NOTE: *Use a compass to check the accuracy of your clock compass.*

### *Why?*

This compass is most accurate March 21 and September 23 when the Sun rises in the east and sets in the west. On these dates, the shadow of the pin approaches due north as noon nears. At other times of the year, the clock compass loses accuracy, but the general direction of north can be found.




**24—**
**Mirage**

***Purpose***

To determine why the Sun's image is seen before sunrise and after sunset.

***Materials***

modeling clay
small bowl that you can see through
coin
helper
pitcher of water

***Procedure***

• Press a walnut-size clay ball into the center of the small bowl.

• Stick the coin in the center of the clay.

• Place the bowl near the edge of a table.

• Stand near the table so that you can see the entire coin.

• Slowly move backwards until the coin is just barely out of sight.

• Ask your helper to fill the bowl with water.

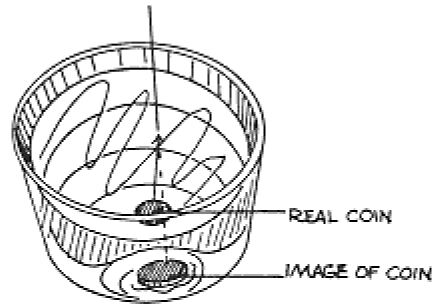
***Results***

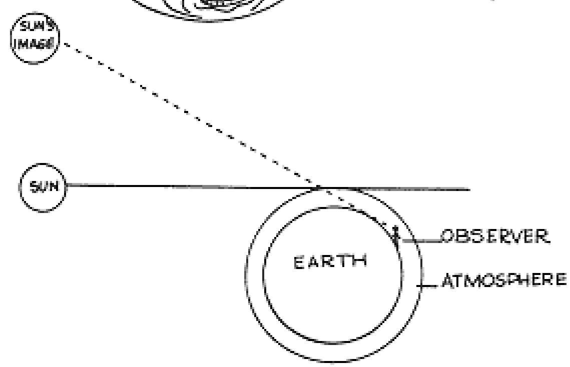
The coin is visible and appears to be in a different position in the bowl.

***Why?***

Light from the coin changes direction as it leaves the water and enters the air. This makes the coin appear to be in a different place. This change in the direction of light is called **refraction.** The Earth's **atmosphere** refracts light in a similar way, causing the image of the Sun to appear before the actual Sun

rises above the horizon at sunrise and lingers after the Sun moves below the horizon at sunset.



## 25— Slanted

### *Purpose*

To determine why the poles of Mars and the Earth are cold.

### *Materials*

2 felt-tipped marking pens
1 sheet of white paper
compass
protractor

### *Procedure*

• Draw a half circle on the paper with a diameter of 8 inches (20 cm) using the compass.

• Use the protractor to identify a 90-degree angle to the paper. Hold the two markers vertically so that they stand side by side.

• Press the markers against the paper to make dots.

• Lift both markers off the paper.

• Hold the markers on top of one another at about a 10-degree angle to the paper. (Use a protractor to measure the angle.)

• Lower the markers until the tip of the lower marker touches the paper within the top of the circle.

• Slide the top marker down until its point touches the paper and press to make a second dot on the paper.

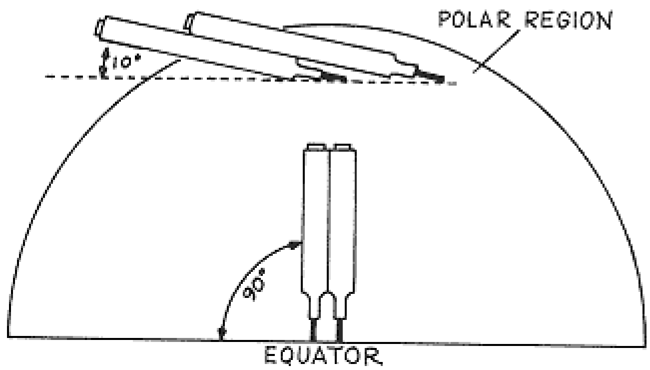
• Compare the distance between the dots at the center to those at the top of the circle.

### *Results*

The dots made by the slanted markers are farther apart.

### *Why?*

The standing markers represent direct rays from the Sun and the leaning markers represent slanting solar rays. Just like the marks left by the pen, the distance between slanting solar rays is greater. Areas that receive direct rays from the Sun are much hotter. The Earth's equator receives about 21/2 times as much heat during the year as does the area around the poles. Mars, like the Earth, has colder pole areas. Both of these planets are slightly tilted from the path of the Sun's rays, causing the center to receive more direct solar rays than do the poles.




**26— Distortion**

***Purpose***

To determine how the atmosphere affects the viewed shape of the Sun.

***Materials***

pencil
1 sheet of white paper
compass
magnifying lens

***Procedure***

• In the center of the paper, draw a circle with about a 1-inch (2.5-cm) diameter using the compass.

• Look through the magnifying lens at the circle.

• Move the lens back and forth as you view the circle.

***Results***

The shape of the circle becomes distorted.

***Why?***

The glass in the magnifying lens has different thicknesses. As light passes through the lens, it changes directions. This change of the light's direction is called **refraction.** The thicker the lens, the more the light is refracted and the more distorted is the circle. The apparent flattening of the Sun at dusk, when it is near the horizon, is due to refraction of light. The rays from the bottom edge of the Sun are closer to the horizon and therefore travel through more of the Earth's **atmosphere** than the rays from the top edge of the Sun. These rays bend toward the Earth as they travel through the thicker section of the atmosphere. The atmosphere, like the magnifying lens, changes the direction of light passing through it, thus distorting the image seen.

CAUTION: *Be very careful never to look directly at the Sun when performing this experiment. Even the setting Sun can burn the delicate retina in your eyes.*

## 27— Sky Path

### *Purpose*

To demonstrate the apparent path of the Sun across the sky.

### *Materials*

pencil
sheet of white paper
2-quart (2-liter) round glass bowl
marking pen
compass

### *Procedure*

• Mark an X in the center of the paper.

• Place the paper outside in direct sunlight.

• Turn the bowl upside down over the paper, having the X in the center of the bowl.

• Touch the sides of the bowl with the tip of the pencil so that the shadow of the pencil's tip falls on the X mark.

• With the pen, make a dot on the glass where the pencil touches the glass.

• Continue to make marks every hour throughout the day.

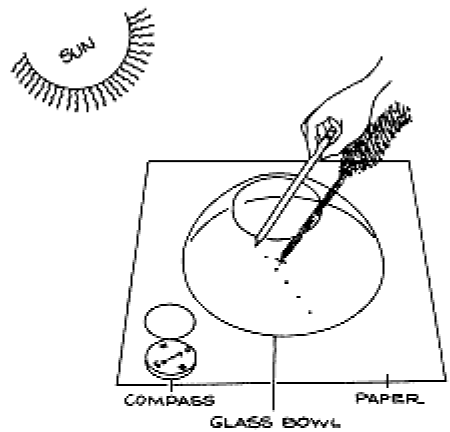
• Use a compass to determine the direction of the Sun's movement.

### *Results*

A curved path starting in the eastern sky and ending in the western sky is marked on the glass as the Sun appears to move across the sky.

### *Why?*

The Sun is not moving from east to west, but rather the Earth is turning toward the east. The Earth rotates once every 24 hours, giving the illusion that the Sun rises in the east, reaches its highest point in the sky at noon, and then begins to sink in the west. Because the Earth's axis is tilted, the Sun actually rises due east and sets due west only during spring and fall months. In the winter months, the Sun rises in the southeast and sets in the southwest. In the summer months, the Sun rises in the northeast and sets in the northwest.




**28—**
**Blasters**

### *Purpose*

To determine what might have produced the craters on the Moon.

### *Materials*

2-quart (2-liter) plastic bowl
flour
3 or 4 sheets of newspaper
baseball

### *Procedure*

• Fill the bowl 3/4 full with flour.

• Spread the newspaper on the floor.

• Place the bowl of flour in the center of the newspaper.

• Stand with the bowl at your feet and the ball level with your chest.

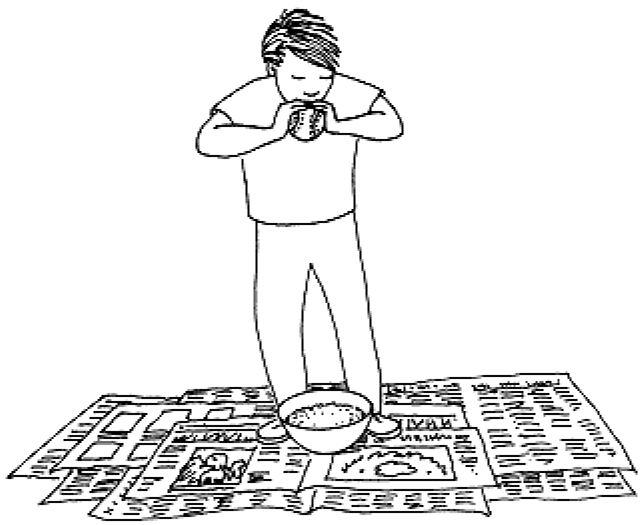
• Drop the ball into the bowl.

### *Results*

The balls sinks into the flour and some flour dust flies upward from its surface.

### *Why?*

The surface of the Moon is pitted with **craters** (holes) ranging in size from tiny pits called craterlets to large basins many miles across called walled plains. Most craters were probably caused by high-speed **meteorites** (stony or metallic objects from space that reach the surface of a celestial body) crashing onto the Moon. The baseball represents a meteorite crashing into the surface of the Moon (the flour). Unlike the baseball, the high-speed meteorites explode on impact and scatter over a large area leaving only a large hole behind.



## 29— Changes

### *Purpose*

To determine why the Moon appears and disappears.

### *Materials*

pencil
styrofoam ball the size of an apple
lamp

### *Procedure*

• Push the pencil into the styrofoam ball.

• Position the lamp near a doorway.

• Stand in a darkened room facing the lighted doorway.

• Hold the ball in front of you and slightly higher than your head.

• Slowly turn yourself around. Keep the ball in front of you as you turn.

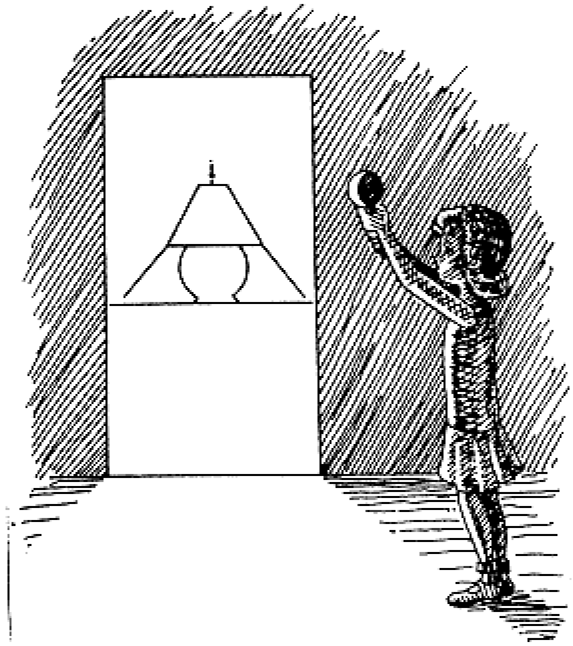
• Observe the ball as you turn.

### *Results*

The ball is dark when you face the door. Part of the ball lightens as you turn and it is fully illuminated when your back is to the door. The ball starts to darken as you turn toward the door.

### *Why?*

The light from the doorway lights up one side of the ball at a time—the side facing the lamp. As you turn, more of the lighted side faces you. The Moon behaves like the ball. Moon light is a reflection of the Sun's light, and only one side of the Moon faces the Sun. The Moon has phases because as the Moon travels around the Earth, different parts of its bright side are seen.



**30—**
**Reflector**

### *Purpose*

To determine how the Moon shines.

### *Materials*

modeling clay
hand mirror
flashlight

### *Procedure*

NOTE: *Perform this experiment in a darkened room.*

• Use a piece of clay to hold the mirror upright on the table.

• Hold the front of the flashlight at an angle to the mirror.

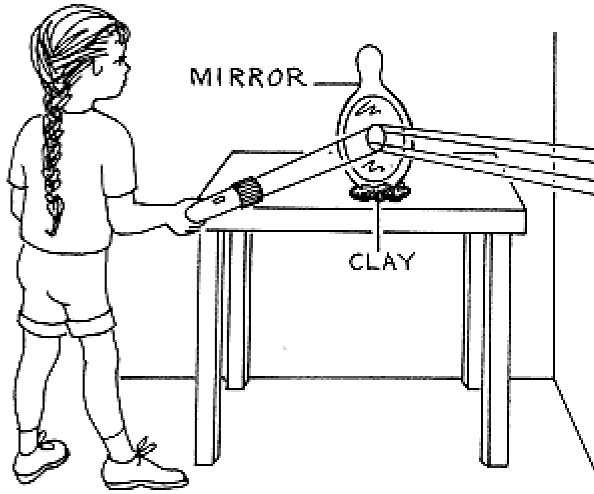
• Turn the flashlight on then off.

### *Results*

The mirror looks bright and a circle of light is seen on the wall.

### *Why?*

The mirror does not give off light, but can reflect light. A beam of light reflects from the mirror and hits a wall when the flashlight is on. The Moon is not a **luminous body** (object that gives off its own light). The Moon only reflects light from the Sun. Without the Sun, there would be no moonlight.


MIRROR
CLAY

## 31— Sender

### *Purpose*

To determine how starlight travels.

### *Materials*

rectangular baking dish
tap water
2 ping pong balls

### *Procedure*

• Place the dish on a table.

• Fill the dish with about 1 inch (2.5 cm) of water.

• Place a ball on the surface of the water at each end of the dish.

• Push one of the balls beneath the surface of the water and release it.

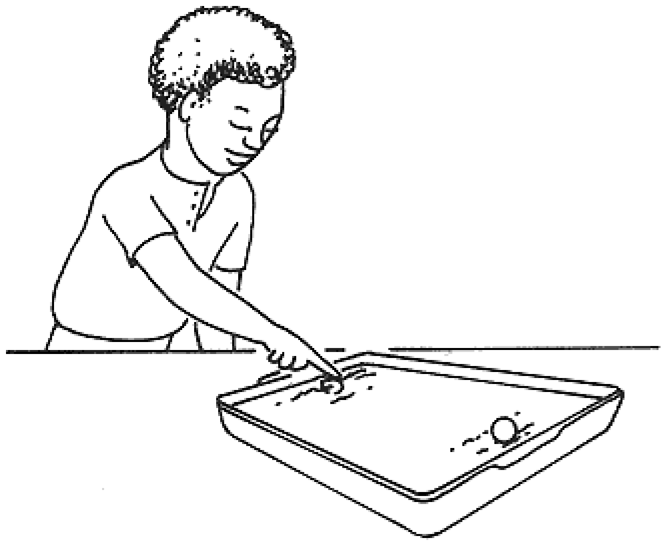
• Observe the balls and any movement of the surface of the water.

### *Results*

The submerged ball rises and waves move quickly toward the second ball. The second ball rises and falls.

### *Why?*

Pushing the ball into the water causes the water to rise and fall in waves. Like a water wave, a wave of light from a star or any light source is a rising and falling disturbance that transfers energy from one point to another without the actual transfer of the material. The energy of the moving water is transferred from one water molecule to the next, causing waves to move across the surface of the water and lifting the second ball.



## 32— Spreader

### *Purpose*

To demonstrate how distance affects a star's apparent brightness.

### *Materials*

flashlight

### *Procedure*

NOTE: *Perform this experiment in a darkened room.*

• Stand in the center of a darkened room and shine the flashlight at a wall.

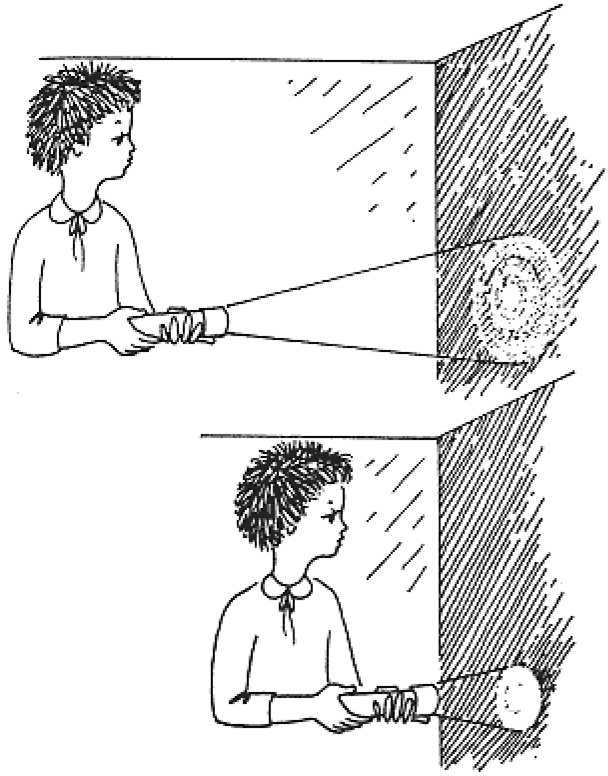
• Slowly walk toward the wall and observe how the light pattern produced on the wall changes.

### *Results*

The light pattern becomes brighter and smaller as the flashlight nears the wall.

### *Why?*

Light moves away from the flashlight in a straight line. If the beam of light leaves the light source at an angle, it continues to spread out until it hits an object. Other light sources, such as stars, behave in the same manner. Two stars giving off the same amount of light, but at different distances from the Earth, will appear to have different **magnitudes** (degrees of brightness). The spreading of the light from the most distant star results in less light hitting the Earth. Thus, the distant star appears dimmer, as did the light when the flashlight was farthest from the wall.



## 33—
## Hazy

### *Purpose*

To demonstrate why the Milky Way appears to be a hazy cloud.

### *Materials*

paper hole punch
white paper
glue
black construction paper
masking tape

### *Procedure*

• Use the hole punch to cut about 20 circles from the white paper.

• Glue the circles very close together, but not overlapping, in the center of the black paper.

• Tape the paper to a tree or any outside object.

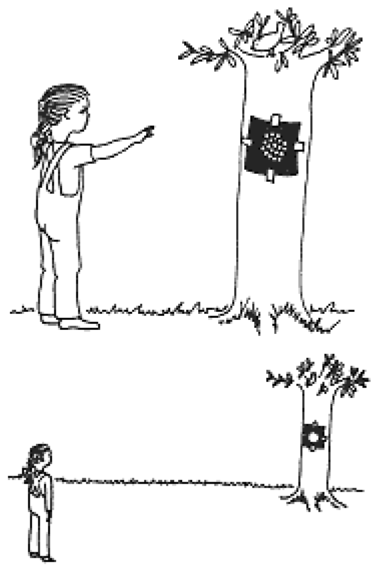
• Stand close and look at the paper, then slowly back away until the separate circles can no longer be seen.

### *Results*

The separate circles can be seen when standing close to the paper, but at a distance, the circles blend together to form one large white shape.

### *Why?*

Due to the inability of our eye to distinguish discrete points of light that are too close together, the separate circles blend together as does the light from distant stars. Using binoculars or a telescope helps our eyes to see stars more clearly. The Milky Way **galaxy** is a group of stars including our Sun. Part of that galaxy appears as a milky haze in the night sky. This hazy light is actually light from billions of stars so far away that their light blurs. This haziness is partly due to the inability of our eyes to separate distant light sources, but great amounts of galactic dust also scatter and block the starlight from the Milky Way.



## 34— Unequal

### *Purpose*

To determine why variable stars pulsate.

### *Materials*

9-inch (23-cm) round balloon

### *Procedure*

• Partially inflate the balloon. Keep the end of the balloon in your mouth during the experiment.

• Use the pressure of your breath to keep the air from escaping.

• Force more air into the balloon.

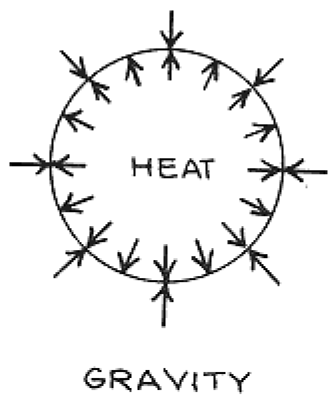
• Allow some of the air to escape.

### *Results*

The balloon increases and decreases in size.

### *Why?*

The balloon changes in size because the air pressure inside the balloon changes, and the balloon stretches and shrinks as the air inside changes. **Cepheids** (stars that have regular pulsations) are variable stars that, like the balloon, change size depending on internal pressures. These stars, unlike others, are not at equilibrium, meaning that their gravity pulling inward does not equal the pressure due to heat pushing outward. As cepheids change size, they also change temperature and give off a different amount of light. When hottest, the star appears yellow and when cool, it looks orange.


HEAT
GRAVITY

## 35— Burn Out!

### *Purpose*

To determine the cause of "shooting stars."

### *Materials*

hammer
nail
block of wood

### *Procedure*

• Partially hammer the nail into the wooden block.

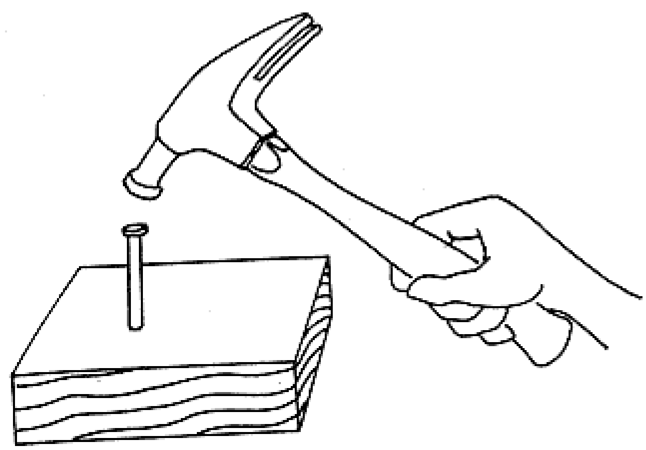
• Carefully touch the head of the nail with your fingers.

### *Results*

The nail head is hot.

### *Why?*

Rubbing two objects together causes **friction.** Friction between the hammer and the nail produces heat as does the rubbing together of a **meteor** and air molecules in the Earth's **atmosphere. Meteoroids** are variable-sized pieces of materials floating through space. If the meteoroid gets close enough, Earth's gravity pulls it into the atmosphere. The friction of the fast-moving meteoroid against the air molecules causes the meteoroid to heat up and glow. This glowing mass is now called a meteor. Meteors usually burn up before reaching the Earth's surface. The flash of light as the glowing meteor burns is called a "shooting star." Showers of meteors occur each year around January 3, August 12, October 21, and December 14 because on these dates the Earth passes through the orbits of various comets. Matter in the comet's orbit is pulled into the Earth's atmosphere. If a meteor reaches the Earth's surface, it is called a **meteorite.** Most meteorites are as small as dust particles or sand grains, but larger pieces have struck the Earth.



**36—**
**Silhouette**

### *Purpose*

To simulate an absorption nebula.

### *Materials*

table lamp
1 sheet of white paper
pencil

### *Procedure*

NOTE: *Perform this experiment in a darkened room.*

- Turn the table lamp on.

- Hold the sheet of paper about 1 yard (1 m) in front of the lamp.

- Place the pencil about 2 inches (5 cm) from the paper on the side facing the lamp.

- Look at the paper facing you.

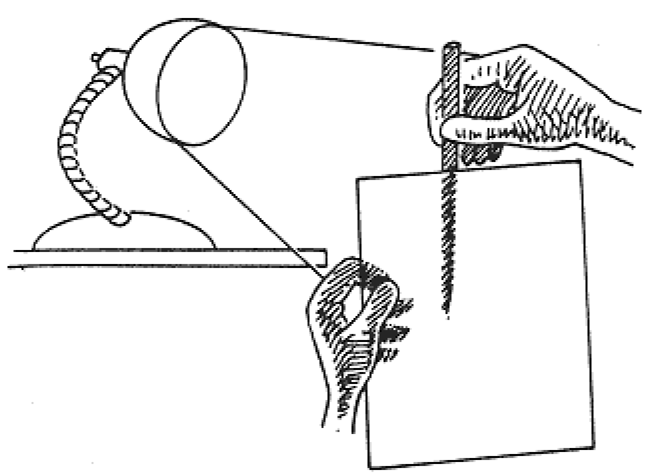
### *Results*

A silhouette of the pencil forms on the paper.

### *Why?*

A **nebula** is a vast cloud of dust and gas in space. There are three classes of nebulae—absorption nebulae that block light, emission nebulae that glow, and reflection nebulae that reflect light from other objects.

The silhouette of the pencil simulates an absorption nebula, which blocks the light coming from behind it and appears as a dark silhouette. The shapes of these clouds in the heavens are due to the concentration of the particles making up the nebula that blocks the light of distant stars.



## 37—
## Star Chart

### *Purpose*

To record the position of the Big Dipper and Polaris.

### *Materials*

| | |
|---|---|
| scissors | white poster paper |
| ruler | marker |
| string | helper |
| large nail | |

### *Procedure*

• Cut a string 12 inches (30 cm) longer than your height.

• Tie one end of the string to a nail.

• On a clear, moonless night, lay a sheet of white poster paper on the ground.

• Stand on the edge of the paper and point to a star in the Big Dipper constellation while holding the free end of the string, allowing the nail to hang freely.

• Ask a helper to mark a spot on the paper under the hanging nail.

• Point to each of the stars in the Big Dipper as your helper marks their position on the paper.

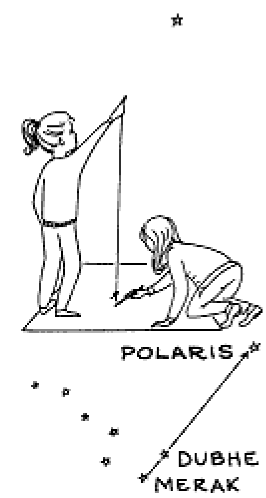
• Find and mark the position of the North Star by drawing a straight line from the two pointer stars in the bowl of the Big Dipper to the star in the handle of the Little Dipper constellation.

### *Results*

The position of the **constellation** (group of stars that, viewed from the Earth, form the outline of an object or figure) called the Big Dipper is drawn on the paper and **Polaris,** the North Star, is plotted on the star chart.

### *Why?*

As your finger moves from one star to the next, the free hanging nail moves to a new position, thus plotting the position of the stars. Polaris, the star that the Earth's imaginary axis points to, is also called the North Star. This star can be found by following the two pointer stars, Dubhe and Merak, in the bowl of the Big Dipper.




**38—**
**How Far?**

***Purpose***

To demonstrate why it would be useful to place a large optical telescope on the Moon.

***Materials***

clear plastic report folder
freezer

***Procedure***

- Look through the plastic folder at a distant object.

- Place the plastic folder in a freezer.

- After 5 minutes, remove the folder from the freezer.

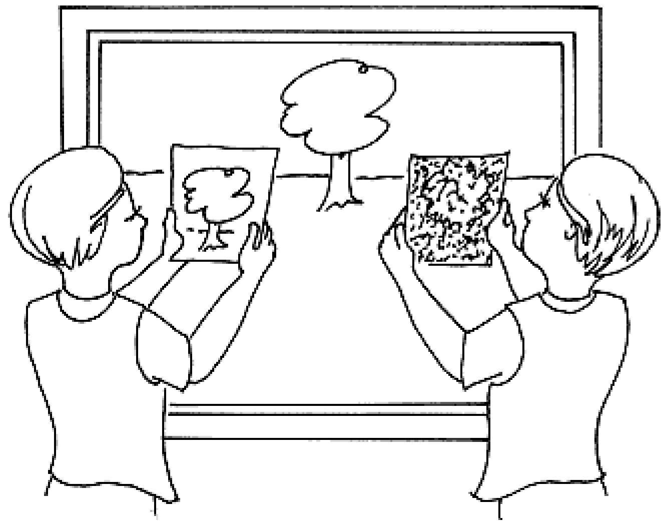
- Again, look through the plastic folder at the same distant object.

***Results***

Cooling the plastic folder caused it to become cloudy. It was easy to see through the plastic before it was cooled.

***Why?***

The moisture in the air **condensed** (changed from a gas to a liquid) on the surface of the cool plastic folder causing it to look cloudy. Clouds form in the Earth's **atmosphere** because of the condensing of water vapor similar to the cloudy covering on the plastic. There is no appreciable atmosphere on the Moon to form clouds so the view of distant objects is always unobstructed.



## 39— Details

### *Purpose*

To demonstrate the resolution of a lens.

### *Materials*

scissors
black construction paper
flashlight
masking tape
straight pen

### *Procedure*

• Cut a circle of paper to fit over the end of the flashlight.

• Secure the paper to the flashlight end with tape.

• Use the pin to make two holes in the center of the paper circle about the width of the pencil lead apart.

• Place the flashlight on a table.

• Stand near the flashlight, facing the two spots of light emitted.

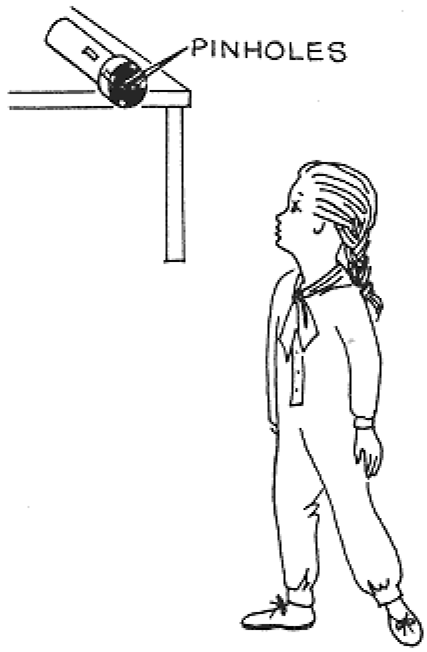
• Slowly walk backwards until the spots look like one dot.

### *Results*

The two holes appear as one beam of light from a distance.

### *Why?*

**Resolution** measures the ability to see details. This is true with your eyes as well as with telescopes. The resolving power of a telescope lens indicates the lens's ability to distinguish between the images of two points. The greater the resolution, the better one can see the object studied. The resolving power of a lens increases with the diameter of the lens. Atmospheric conditions also affect resolving power.




**40—**
**Streamers**

***Purpose***

To determine why a comet's tail points away from the Sun.

***Materials***

modeling clay
scissors
ruler
string
pencil
fan

***Procedure***

• Form a clay ball the size of a lemon.

• Cut four 6-inch (15-cm) pieces string.

• Use the pencil point to push one end of each string into one side of the ball. Space the strings equally around the front of the ball.

• Stick the pencil point into the bottom of the ball.

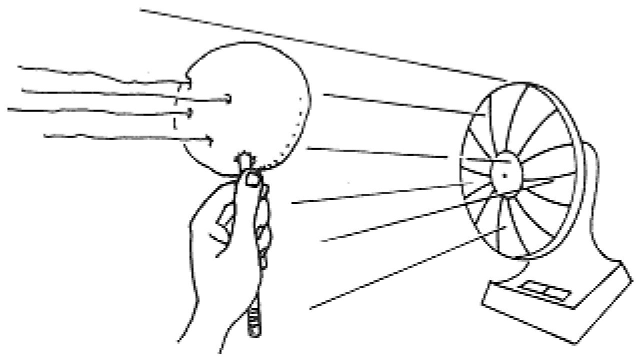
• Hold the ball in front of a fan with the strings pointing away from the fan.

***Results***

The strings fly out away from the fan.

***Why?***

The wind pressure from the fan pushes the strings away. The strings simulate the tail of a **comet** (cloud of frozen gases, ice, dust, and rock orbiting the Sun). Solar radiation pressure and solar winds cause the comet's tail, which is made of gases and dust, to stream out away from the Sun.



**II—**
**Biology**